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R.P.E. TECH. NOTE
No.195

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No.195



CONFIDENTIAL



# ROCKET PROPULSION ESTABLISHMENT

WESTCOTT, BUCKINGHAMSHIRE



R.P.E. TECHNICAL NOTE No: 195

# THE DEVELOPMENT OF THE GOSLING II SOLID PROPELLENT ROCKET MOTOR

by

E. C. WHITE



OCTOBER, 1960



MINISTRY OF AVIATION





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Technical Note No. 195

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5 E. C. White


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## SUMMARY

The development of a motor in which the cordite charge of the Gosling I is replaced by a case-bonded plastic propellent is described.

Using the same motor tube an increase of 40% in total impulse was obtained, with a motor operating reliably within the temperature limits -5 to 50°C. These limits are sufficiently wide for a boost motor in the development phases of a guided missile or high speed test vehicle.


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## 1 INTRODUCTION

This note describes the development of the Gosling II rocket motor which was produced, primarily as a development exercise, at R.P.E. Westcott, but also with the intention of having a design available to meet a possible future use requirement.

The history of ground-to-air missiles has shown a continuing trend towards higher performance boost motors, as shown in the following table:-

| Motor | Number of boosts per missile set | Total impulse per set, lb - sec |
|---|---|---|
| Demon | 8 | 180,000 |
| Mayfly III | 4 | 208,000 |
| Mayfly IV | 4 | 236,000 |
| Gosling I | 4 | 250,000 |

In view of this background, the desirability of a boost motor of higher performance, which, if required, would be capable of replacing the Gosling I motor[1] was apparent. The simplest method of effecting this was considered to be by replacing with plastic propellent the cordite charge used in Gosling I and utilising the motor tube of the existing design. A similar procedure had been adopted in developing the Mayfly IV motor which is a plastic propellent version of Mayfly I[2] and retains the same tube.

Since the new motor was produced purely for development purposes the desired feature was the highest total impulse attainable in the shortest burning time. On examination it was found that the charge conduit design used with the Mayfly IV motor would be suitable for the 10-inch diameter Gosling tube, giving a charge weight of 405 lb. A propellent having a predicted specific impulse of 215 lb-sec/lb would enable a total impulse of 87,000 lb-sec to be developed.

## 2 MOTOR DESIGN

### 2.1 Empty components

The Gosling motor tube (Fig.1) is of conventional design comprising a wrapped and welded shell in 16 swg steel to specification SAE4130 to which are welded the head-end pressing and rear-end threaded ring. The tube is subjected to a hydraulic test pressure of 1700 lb/sq in. prior to filling. As indicated above, its use with Gosling II involves no change in external dimensions, which is clearly desirable should a missile contractor wish to install Gosling II motors using missile attachment fittings designed to accept Gosling I. Each missile, however, requires a tube which, although basically the same, differs slightly in minor external dimensions. Details of the different versions of Gosling II motors are shown in Table I.

The steel end-plate to specification DEF13 group 3B is attached to the tube by means of a large diameter screw thread, and has a central hole sufficiently large to accommodate the former required for pressing the propellent charge.

The venturi-nozzle comprises a throat portion fabricated in steel to specification DEF13 group 3B to which is welded a wrapped expansion cone in 12 swg steel. The whole of the internal surface is sprayed with alumina to a thickness diminishing uniformly from 0.020 inch at the throat to 0.005 inch at the exit. A description of this process and the events leading to its introduction in the Gosling II motor are detailed elsewhere[3]. The axis of

the nozzle is inclined to that of the tube at an angle varying between $0^{\circ}$ and $15.5^{\circ}$ depending on the application. The nozzle is attached to the end-plate by a ring of set-screws for offset nozzles and by a screw thread for in-line nozzles.

Typical physical and internal ballistic characteristics of the motor are given in Appendix I.

## 2.2 Propellent charge

The dimensions of the existing former were such as to produce a charge of web thickness 2.01 inch in a 10-inch diameter tube (Fig.2). With a fixed charge design and a pressure limited by the strength of the tube, two characteristics only can be varied; the propellent burning rate and the nozzle-throat size. To attain the shortest burning time the cross-sectional area of the throat must be made as large as possible so that the fastest burning propellent, for a given pressure, may be used. The limiting size for the throat area is reached when the ratio of the cross-sectional area of the conduit to that of the throat is reduced to a point at which propellent erosive burning produces an unacceptably high initial peak pressure. Experience with the Mayfly IV motor had shown that a value of 1.5 : 1 for this ratio produced no appreciable erosive burning and it was considered that a reduction to 1.3 : 1 might be possible. A throat diameter of 4.4 inches required with the conduit area of 20.07 sq in. produced the 1.3 : 1 ratio. The results obtained when attempts were made to reduce this ratio still further will be reported elsewhere.

It was considered that mean and maximum working pressures of 1180 and 1400 lb/sq in. in motors fired at + 15°C would give an adequate margin of safety below the test pressure of the tube (1700 lb/sq in.) when motors were fired at a conditioning temperature of 50°C.

The plastic propellent RD2304G (see Appendix II) was selected as producing a mean pressure of 1180 lb/sq in. when fired with a restriction ratio of 214 : 1. From the known temperature dependance of this propellent, it was calculated that the corresponding mean and maximum pressures at + 50°C would be 1250 and 1500 lb/sq in. respectively. This gives a factor of safety of 1.13 which was considered adequate. The burning rate of RD2304G at 1180 lb/sq in. gives a time of burning of 3.1 seconds at 15°C. The rates of burning of a number of lots of propellent RD2304G determined in the strand burner are given in Table II.

## 2.3 Igniter

The igniter consists of an aluminium canister containing 100 grams of SR371C pyrotechnic composition which is located at the head end of the motor and is supported either on a separate spider or is attached to the pressure plug. An assembled igniter is shown in Fig.3 and fully described in ref.4.

Some early development firings were carried out using a tubular igniter comprising a paper carton 1 inch diameter by 24 inches long and 100 grams of SR371C (Fig.4). It was believed that this type of construction would reduce the ignition shock and would prove beneficial, particularly at low temperature. Further work[5,6], however, showed conclusively that no advantage was gained and its use was discontinued.

# 3 DEVELOPMENT STATIC FIRINGS

During the development, 40 Gosling II motors were fired at ambient temperature with 100% success. Many of these firings were carried out to

assist the missile contractor in the design of boost harnesses and separation mechanisms, or to simulate and investigate anomalous behaviour in flight rounds such as 'g' pulse in Seaslug and flutter in Red Duster. Early firings at low temperature established that $-5^{\circ}C$ was a reasonable lower limit and since this motor was not destined for service use, firings at extremes of temperature were kept to a minimum. Such firings as were carried out at temperatures below $-5^{\circ}C$ were in support of a general investigation into the behaviour of plastic propellent at low temperature and the results have been reported[5,6]. An upper temperature limit of $50^{\circ}C$ was fixed as being adequate to cover the requirements of missiles in research and development phases. Details of a number of these firings are given in Table III. Typical pressure - and thrust-time curves are shown in Fig.5 and 6 respectively. The variation of mean pressure, mean thrust and burning time with operating temperature are shown in Fig.7.

## 4 PROJECTION FIRINGS

The motor was first required to provide the propulsion for a supersonic vehicle. In this application the conditions of velocity (~ 5000 feet/sec after 3.3 seconds) and acceleration (up to 70g) were severe. The contribution made by Gosling II to this work is reported in ref.7. In this connection Gosling II successfully formed the second stage of two and three stage vehicles. It is also in current use for trials purposes as a boost motor for the three major surface to air missiles - Thunderbird, Bloodhound and Seaslug.

A total of 293 motors has been supplied for use on these missiles and details are given in Table I.

To date three failures have been recorded.

Two took the form of instantaneous bursts on or near the launcher; these were pressure bursts resulting from failure of the propellent to bond to the metal, the third occurred late in burning following overheating of the rear-end of the tube. The steps taken to overcome the instantaneous failures were:-

(1) An improved adhesive for bonding the propellent to the tube.

(2) A more rigorous control of the filling and inspection of the motor.

(3) The introduction of an ultrasonic method[8] for detecting the lack of adhesion of the propellent to the tube wall.

The type of failure resulting from detachment of the propellent from the end-plate was obviated by (in addition to the improvements stated above) the insertion of a steel liner at the rear of the tube. This liner, which has a serrated internal surface, has the dual effect of providing a key for the propellent and acting as a heat shield for the tube in the event of lack of adhesion. The method of filling Gosling motors is given in Specifications RPE 1022 and 1029.

## 5 CONCLUSIONS

(1) A 10-inch diameter plastic propellent boost motor using a charge of increased performance in an existing tube has been fired successfully on guided missiles and high speed test vehicles under conditions of high acceleration.

(2) The advantages of plastic propellent are such as to increase the total impulse by 24,500 lb-sec, or 40% over Gosling I. This increase is gained by greater loading density (approx 29% more propellent) and higher specific impulse (about 8%) of the propellent.

(3) The motor ignites and performs reliably within the temperature limits -5 to +50°C.

---

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| No. | Author | Title, etc. |
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| 7 | Picken, J. | Notes on the progress of free flight trials to measure heat transfer at Mach numbers up to 5<br>R.A.E.Tech.Note No. Aero 2575 June 1958 |
| 8 | Lister, R. | An ultrasonic method of detecting lack of adhesion between case-bonded plastic propellent and the tube wall in rocket motors<br>R.A.E.Tech.Note No.RPD156 November 1957 |


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ATTACHED:-

Appendices I and II
Tables I to III
Drgs.No. RP 2837-2840
Detachable abstract cards

ADVANCE DISTRIBUTION:-

MOA

| | | |
|---|---|---|
| CGWL | AD/GW (P & W) | |
| CM | AD/MXRD (X) | |
| DG/GW | ADSR (Records) | |
| D/GW(Air) | D/ERDE | 3 |
| D/GW(N) | RAE Farnborough | 5 |
| D/GW(Tech) | Sec EDPC | |
| DMXRD | GW(A)1(b) | 70 |
| DI Arm | TIL 1(b) | 100 |

# APPENDIX I

## Leading physical and internal ballistic characteristics of Gosling II motor

### Weights (Gosling II Series G taken as typical)

| | |
|---|---|
| Motor tube | 98 lb |
| End-plate | 15 lb |
| Venturi nozzle | 23 lb |
| Filled igniter and support | 4 lb |
| Empty assembly | 140 lb |
| Charge | 405 lb |
| All-up weight | 545 lb |

### Charge

| | |
|---|---|
| Propellent | RD2304G |
| Length | 113 inches |
| Diameter | 10.0 inches |
| Web thickness | 2.01 inches |
| Initial burning surface area | 2760 sq.inches |
| Final burning surface area | 3590 sq.inches |
| Initial cross-sectional area of conduit | 20.07 sq.inches |

### Internal Ballistic Characteristics

| | |
|---|---|
| Throat diameter | 4.36 inches |
| Throat cross-sectional area | 14.92 sq.inches |
| Initial burning surface area/throat area | 185 : 1 |
| Final burning surface area/throat area | 241 : 1 |
| Initial cross-sectional area of conduit/throat area | 1.34 : 1 |

### Performance

| | |
|---|---|
| Total impulse | 87,000 lb-seconds |
| Burning time at 18°C | 3.1 seconds |
| Mean thrust at 18°C | 26,000 lb |
| Mean pressure at 18°C | 1,180 lb/sq in. |
| Temperature limits | -5 to +50°C |
| Firing current | 1.5 to 2.0 mA |
| Circuit resistance | approximately 3.0 ohms |

# APPENDIX II

## Characteristics of propellent RD2304G

* Composition

| | |
|---|---|
| Ammonium percholate | 70.5 per cent |
| Ammonium picrate | 15.0 per cent |
| Polyisobutylene | 12.5 per cent |
| Lecithin | 1.0 per cent |
| Titanium dioxide | 1.0 per cent |

* Physical properties

| | |
|---|---|
| Density | 1.684 gm/cc |
| Thermal conductivity, at 30°C | 0.0009 cal $cm^{-1}$ deg $C^{-1}$ $sec^{-1}$ |
| at 60°C | 0.0011 cal $cm^{-1}$ deg $C^{-1}$ $sec^{-1}$ |
| at 100°C | 0.0125 cal $cm^{-1}$ deg $C^{-1}$ $sec^{-1}$ |
| Specific heat | 0.293 cal/g deg C |

Internal ballistic data

| | |
|---|---|
| Burning rate at 1000 lb/sq in. and 25°C | 0.610 in/sec |
| Gas temperature, Tc at 1000 lb/sq in. | 2350°K |
| Characteristic exhaust velocity $\int \frac{P\,dt\,A_t}{M} g$ | 4620 ft/sec |
| Theoretical specific impulse | 233 lb-sec/lb |
| Discharge coefficient($C_D$) | 0.00675 |
| Mean molecular weight of gaseous products | 22.67 |
| Ratio of specific heats | 1.27 |

Equilibrium gas composition

| | |
|---|---|
| $H_2O$ | 28.6 per cent mole fraction |
| $CO_2$ | 6.3 per cent mole fraction |
| CO | 23.7 per cent mole fraction |
| $H_2$ | 17.9 per cent mole fraction |
| H | 0.1 per cent mole fraction |
| $N_2$ | 9.7 per cent mole fraction |
| HCl | 13.7 per cent mole fraction |

* Information kindly supplied by D/ERDE, Waltham Abbey

TABLE I

Versions of Gosling II motor for missile boost or vehicle application and numbers supplied

| Motor | Venturi offset angle, ° | Application | Number of motors supplied by | | |
|---|---|---|---|---|---|
| | | | RPE | ROF Bridgwater | Total |
| Series C | 0 | Supersonic vehicles, Panther, Puma, Regulus, Tiger I | 47 | 10 | 57 (1) |
| D | 0 | Supersonic vehicle Leopard (forms second stage) | 2 | 0 | 2 |
| E | $15\frac{1}{2}$ | Thunderbird | 68 | 48 | 116 (2) |
| G | $11\frac{1}{2}$ | Bloodhound | 4 | 50 | 54 |
| J | 15 | Seaslug | 25 | 24 | 49 |
| K | 14 | Thunderbird | 4 | 8 | 12 |
| M | $4^\circ 55'$ | Supersonic vehicle, Tiger IV | 0 | 2 | 2 |
| N | 0 | Supersonic vehicle; forms second stage of 3-stage vehicle | 1 | 0 | 1 |
| | | Totals | 151 | 142 | 293 |

Notes: (1) One failure - instantaneous burst just after launch

(2) Two failures - one instantaneous burst on launcher
one thermal burst near end of boost burning

TABLE II

Burning rates of propellents RD2304A and RD2304G

Propellent formulation

| RD2304A * | | RD2304G * | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lot No. | Rate, in/sec | Lot No. | Rate, in/sec | Lot No. | Rate. in/sec | Lot No. | Rate, in/sec | Lot No. | Rate, in/sec |
| 1 | 0.597 | 1 | 0.613 | 15 | 0.603 | 29 | 0.602 | 43 | 0.604 |
| 2 | 0.601 | 2 | 0.616 | 16 | 0.613 | 30 | 0.616 | 44 | 0.601 |
| 3 | 0.605 | 3 | 0.620 | 17 | 0.617 | 31 | 0.617 | 45 | 0.611 |
| 4 | 0.627 | 4 | 0.619 | 18 | 0.611 | 32 | 0.605 | 46 | 0.608 |
| 5 | ∅ | 5 | 0.610 | 19 | 0.616 | 33 | 0.610 | 47 | 0.613 |
| 6 | 0.637 | 6 | 0.613 | 20 | 0.610 | 34 | 0.614 | 48 | 0.614 |
| 7 | 0.628 | 7 | 0.616 | 21 | 0.605 | 35 | 0.607 | 49 | 0.607 |
| | | 8 | 0.617 | 22 | 0.610 | 36 | 0.611 | 50 | 0.607 |
| | | 9 | 0.617 | 23 | 0.611 | 37 | ∅ | 51 | 0.607 |
| | | 10 | 0.607 | 24 | 0.605 | 38 | 0.605 | 52 | ∅ |
| | | 11 | 0.605 | 25 | 0.601 | 39 | 0.608 | 53 | 0.608 |
| | | 12 | 0.612 | 26 | 0.611 | 40 | 0.607 | 54 | 0.604 |
| | | 13 | 0.613 | 27 | 0.608 | 41 | 0.602 | | |
| | | 14 | 0.602 | 28 | 0.605 | 42 | 0.610 | | |

* Propellents RD2304A and RD2304G are identical in every respect; the change of nomenclature arose from confusion resulting from a clerical error. All propellent was made at ROF Bridgwater.

∅ These lots were re-blended.

All burning rates were determined at ROF Bridgwater or at RPE on strands 4.5 mm diameter at 1000 lb/sq in.

TABLE III

Static firing results

| Round No. | Date | Propellent | | Charge weight, | | Igniter housing | Ignition delay, second | Burning time, seconds | Total impulse, lb-sec | Specific impulse, lb-sec/lb | Mean thrust, lb | Maximum pressure, lb/sq in. | Conditioning temp °C | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Designation | Lot No, | lb | oz | | | | | | | | | |
| 10PWE 97 | 9. 5.57 | RD2304A | WA17 | 406 | 8 | Metal housed | 0.12 | 3.28 | 88,900 | 219 | 25,200 | 1470 | -5 | Initial peak pressure |
| " 263 | 7.11.58 | " | 10 | 403 | 8 | " " | 0.02 | 3.38 | 88,400 | 219 | 24,300 | 1390 | " | |
| " 265 | 7.11.58 | " | 10 | 401 | 4 | " " | 0.06 | 3.31 | 90,600 | 226 | 25,600 | 1367 | " | |
| " 5 | 12.10.55 | RD2304 | 44-45 | 412 | 1 | Tubular (1) | 0.04 | 3.29 | 72,380† | 176† | 20,100† | 1200 | Air | † choke firing |
| " 50 | 19. 3.57 | " | 7 | 406 | 14 | " | 0.04 | 3.19 | 88,650 | 218 | 25,600 | 1210 | " | |
| " 53 | 19. 3.57 | " | 8 | 406 | 7 | " | 0.04 | 3.08 | 87,850 | 216 | 26,000 | 1430 | " | |
| " 79 | 4. 2.57 | " | 9 | 406 | 2 | " | 0.04 | 3.15 | 85,200 | 210 | 25,000 | 1370 | " | |
| " 80 | 28. 3.57 | " | 9 | 406 | 14 | " | 0.03 | 3.07 | 88,900 | 218 | 26,700 | 1450 | " | |
| " 99 | 9. 5.57 | " | WA17 | 407 | 0 | Metal housed | 0.09 | 3.13 | 89,500 | 220 | 26,600 | 1420 | " | |
| " 100 | 9. 5.57 | " | WA17 | 406 | 0 | " " | 0.14 | 3.10 | 90,400 | 223 | 27,300 | 1430 | " | |
| " 116 | 25. 7.57 | RD2304A | WA1 | 404 | 13 | Tubular | 0.03 | 3.09 | 88,500 | 219 | 25,300 | 1290 | " | |
| " 117 | 25. 7.57 | " | WA2 | 402 | 0 | " | 0.03 | 3.11 | 89,000 | 222 | 26,600 | 1500 | " | |
| " 118 | 25. 7.57 | " | WA3 | 403 | 12 | " | 0.03 | 3.12 | 88,800 | 220 | 26,400 | 1450 | " | |
| " 187 | 31. 1.58 | " | WA7 | 408 | 12 | " | 0.04 | 3.20 | 87,900 | 214 | 25,700 | 1220 | " | |
| " 188 | 31. 1.58 | " | WA7 | 402 | 14 | " | 0.04 | 3.16 | 88,400 | 220 | 26,500 | 1417 | " | |
| " 213 | 30. 4.58 | RD2304G | 1 & 2 | 407 | 10 | " | 0.04 | 3.10 | 88,900 | 217 | 26,400 | 1377 | " | |
| " 223 | 10. 7.58 | " | 3 & 4 | 406 | 0 | " | 0.04 | 3.04 | 89,600 | 221 | 27,400 | 1357 | " | |
| " 233 | 8. 9.58 | " | 5 & 6 | 406 | 0 | Metal housed | 0.04 | 3.04 | 89,600 | 221 | 27,100 | 1441 | " | |
| " 252 | 5. 9.58 | " | 7,8&9 | 405 | 8 | " " | 0.02 | 3.09 | 90,300 | 223 | 27,000 | Not recorded | " | |
| " 264 | 3.11.58 | " | 10 | 402 | 13 | " " | 0.02 | 3.12 | 82,600 | 206 | 24,300 | 1479 | " | |
| " 283 | 6. 1.59 | " | 11 & 12 | 403 | 10 | " " | 0.07 | 3.20 | 89,500 | 222 | 25,700 | 1378 | " | |
| " 288 | 2.12.58 | " | 7 to 14 | 405 | 0 | " " | 0.02 | 3.11 | 89,200 | 221 | 26,000 | 1399 | " | |
| " 289 | 23.12.58 | " | 7 to 14 | 402 | 10 | " " | 0.02 | 3.16 | 88,500 | 219 | 25,200 | 1387 | " | |
| " 294 | 5. 1.59 | " | 13 & 14 | 402 | 0 | " " | 0.06 | 3.28 | 88,400 | 220 | 25,000 | 1370 | " | |
| " 304 | 11. 4.60 | " | 13 & 14 | 402 | 8 | " " | 0.03 | 3.28 | 86,000 | 215 | 24,300 | 1452 | " | |
| " 312 | 23. 1.59 | " | 15 & 16 | 405 | 0 | " " | 0.04 | 3.15 | 88,000 | 217 | 26,200 | 1457 | " | |
| " 330 | 12. 3.59 | " | 17 & 18 | 399 | 8 | " " | 0.07 | 3.13 | 87,500 | 218 | 26,100 | 1361 | " | |
| " 350 | 9. 4.59 | " | 19 & 20 | 405 | 12 | " " | 0.04 | 3.23 | 87,000 | 214 | 25,600 | 1348 | " | |
| " 361 | 30. 4.59 | " | 19 & 20 | 402 | 10 | " " | 0.06 | 3.21 | 89,600 | 220 | 26,000 | 1400 | " | |
| " 373 | 29. 7.59 | " | 21 to 25 | 403 | 12 | " " | 0.075 | 3.23 | 89,500 | 220 | 25,700 | 1430 | " | |
| " 390 | 17. 9.59 | " | 24 to 26 | 405 | 3 | " " | 0.06 | 3.22 | 88,700 | 218 | 24,400 | 1329 | " | |
| " 391 | 17. 9.59 | " | 24 to 26 | 403 | 4 | " " | 0.10 | 3.22 | 89,000 | 220 | 25,600 | 1436 | " | |
| " 395 | 21. 9.59 | " | 24 to 26 | 406 | 10 | " " | 0.07 | 3.18 | 89,000 | 219 | 25,900 | 1360 | " | |
| " 410 | 14.12.59 | " | 30 | 407 | 8 | " " | 0.07 | 3.08 | 88,700 | 218 | 26,300 | 1368 | " | |
| " 421 | 14. 1.60 | " | 39 | 403 | 8 | " " | 0.11 | 3.19 | 85,900 | 213 | 24,200 | 1330 | " | |
| IIE BGW 28 | 10. 3.60 | " | 38,40,41 | 402 | 8 | " " | 0.10 | 3.11 | 88,830 | 213 | 25,580 | 1352 | " | |
| " 1 | 30. 4.59 | " | 22, 23 | 403 | 0 | " " | 0.08 | 3.18 | 88,680 | 220 | 26,160 | 1478 | " | |
| " 2 | 30. 4.59 | " | 22, 23 | 402 | 0 | " " | 0.07 | 3.16 | 87,860 | 219 | 25,900 | 1390 | " | |
| IIG BGW 11 | 17. 7.59 | " | 27,28,29 | 405 | 0 | " " | 0.04 | 3.11 | 88,980 | 219 | 26,670 | 1480 | " | |
| " 25 | 30. 9.59 | " | 31,32,33 | 407 | 0 | " " | 0.06 | 3.16 | 89,570 | 220 | 26,760 | 1380 | " | |
| " 37 | 3. 11.59 | " | 34,35,36 | 405 | 8 | " " | 0.06 | 3.12 | 88,380 | 218 | 26,000 | 1384 | " | |
| IIM BGW 1 | 13. 4.60 | " | 45,46,47 | 402 | 8 | " " | 0.10 | 3.20 | 88,870 | 220 | 25,520 | 1326 | " | |
| IIK BGW 5 | 18. 3.60 | " | 42,43,44 | 410 | 0 | " " | 0.09 | 3.30 | 89,470 | 212 | 25,200 | 1320 | " | |
| 10 PWE 98 | 30. 5.57 | RD2304A | WA17 | 406 | 8 | " " | 0.10 | 2.82 | - | - | - | 1500 | 50 | Instrumentation failed |
| " 151 | 6.11.57 | " | WA17 | 411 | 0 | Tubular | 0.03 | 2.87 | 91,200 | 222 | 30,000 | 1590 | " | |
| " 262 | 3.11.58 | RD2304G | 10 | 402 | 4 | Metal housed | 0.02 | 2.97 | 84,700 | 211 | 26,300 | 1450 | " | |
| " 266 | 3.11.58 | " | 10 | 402 | 3 | " " | 0.09 | 2.89 | 89,500 | 223 | 28,200 | 1530 | " | |

All igniters contained 100 grams of SR 371C pyrotechnic composition except (1), which contained 150 grams.

All motors were fitted with 4.36 inch diameter nozzles.

Motors prefixed 10PWE were produced at RPE Westcott; those prefixed BGW at ROF Bridgwater.

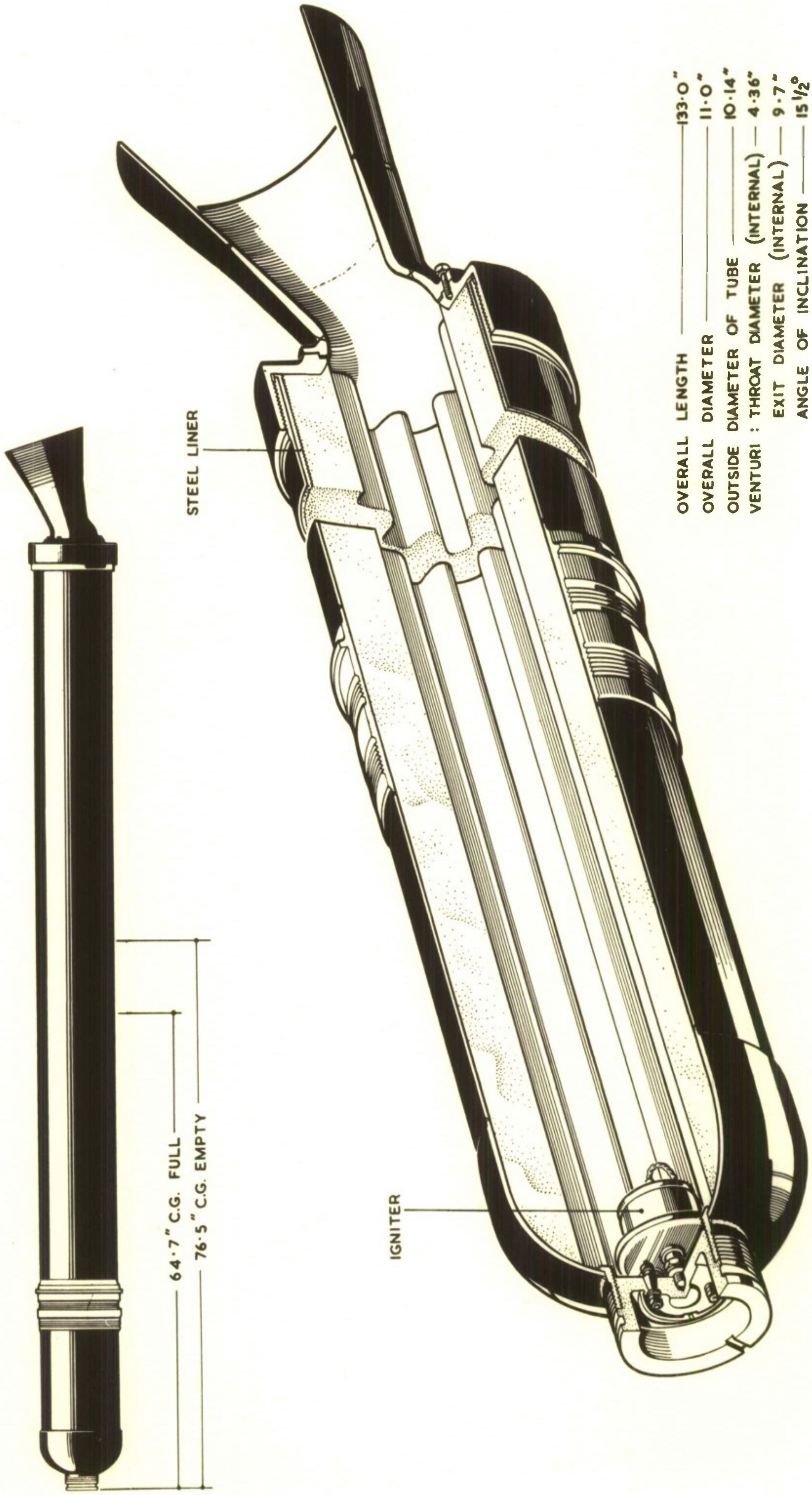



FIG. 1 ASSEMBLY OF GOSLING II MOTOR

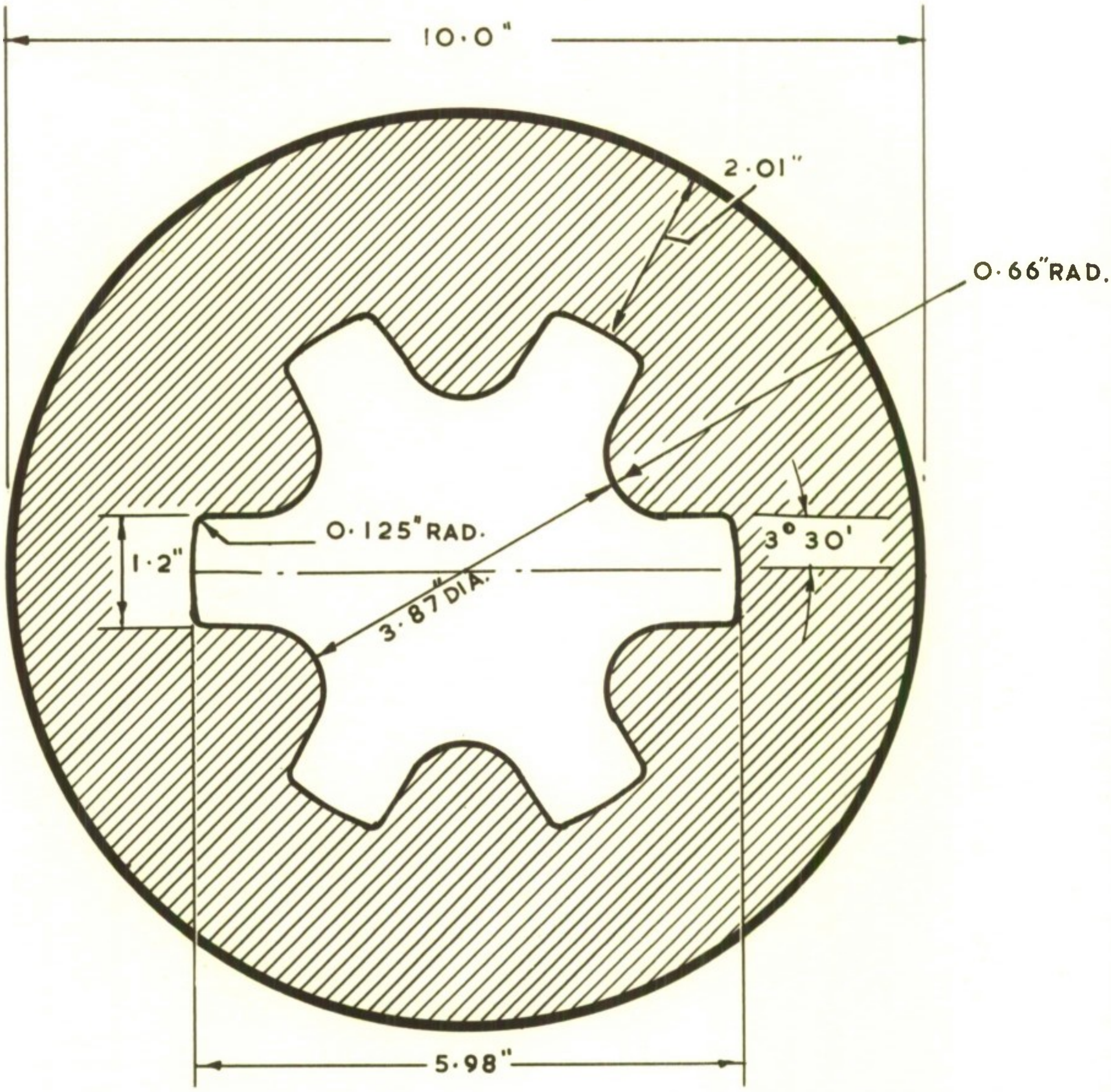



FIG. 2 CHARGE DESIGN C D 43

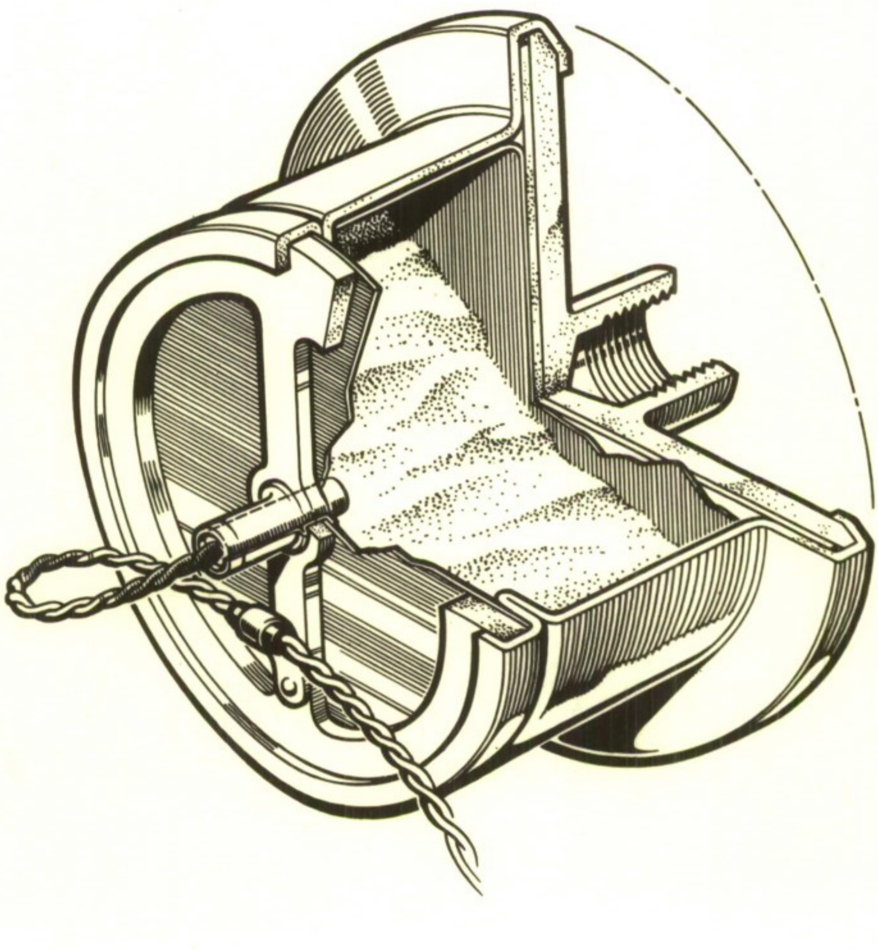
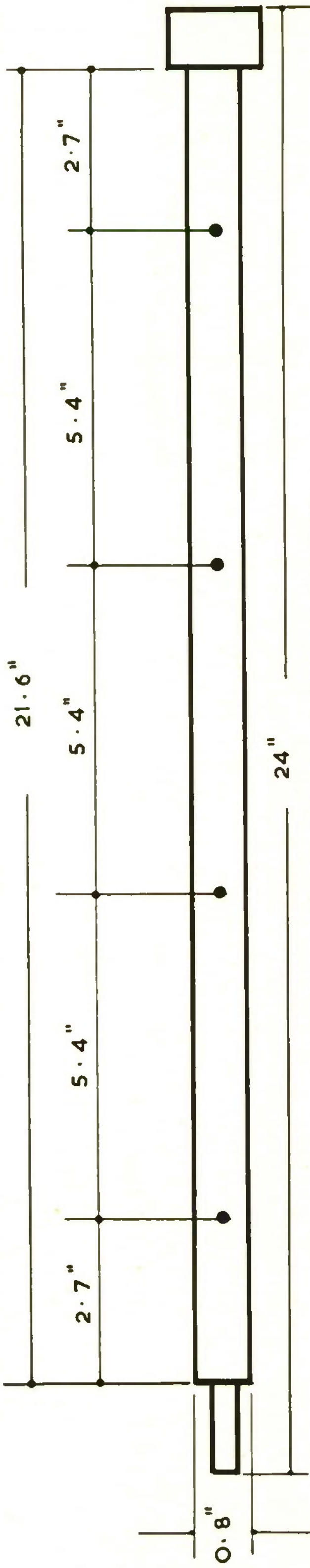


FIG. 3 METAL HOUSED IGNITER




LOCATION OF ELECTRIC FUZES

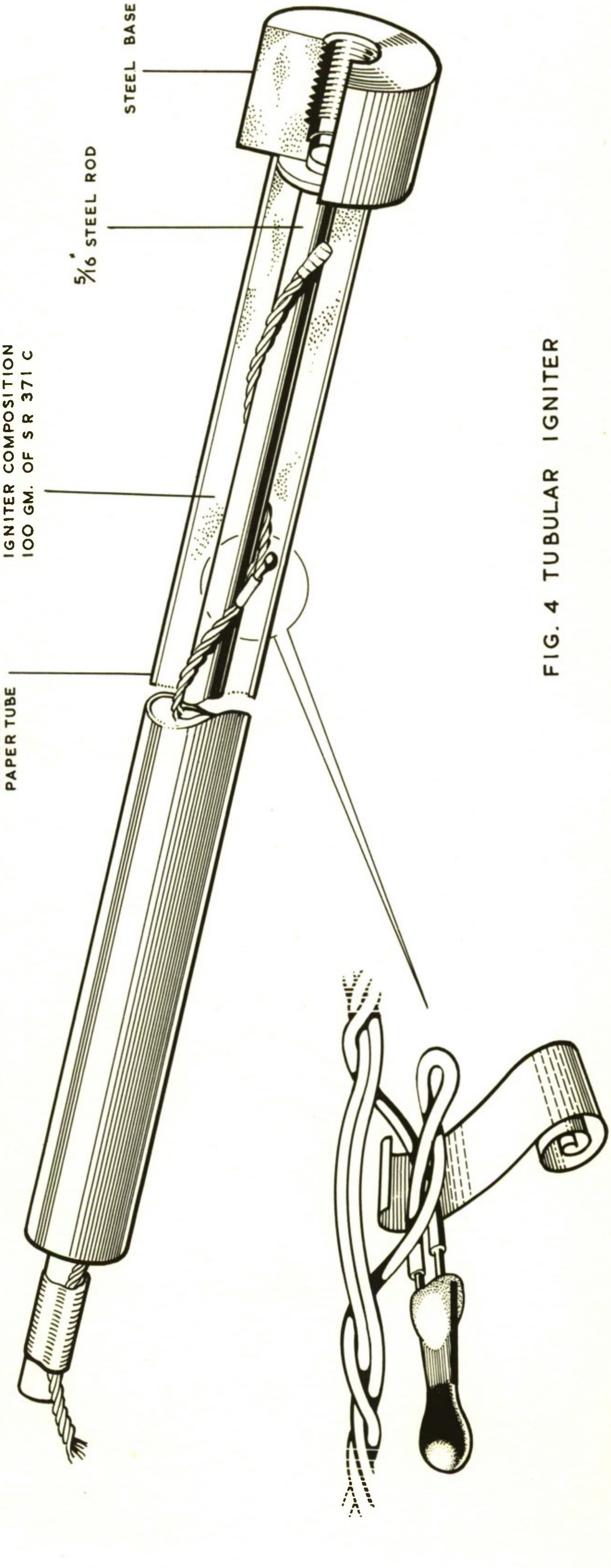



FIG. 4 TUBULAR IGNITER

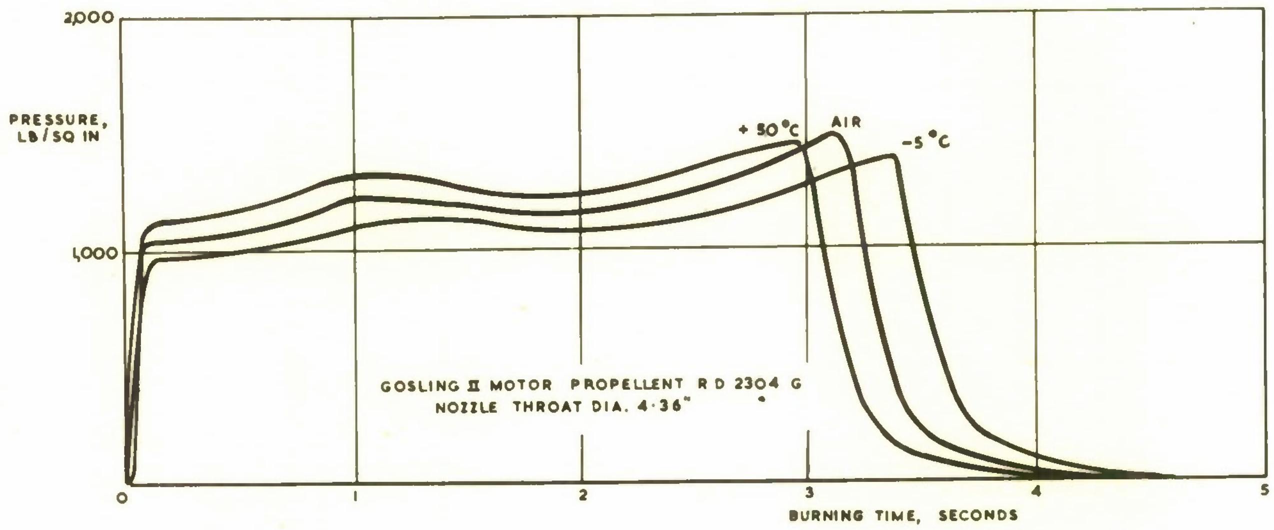



FIG. 5 TYPICAL PRESSURE – TIME CURVES

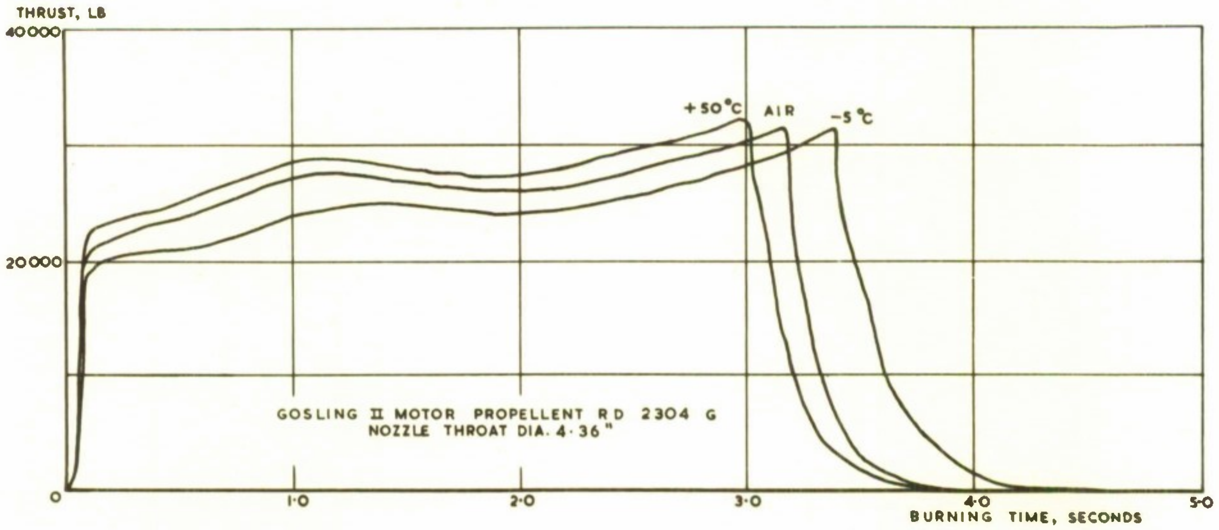



FIG. 6 TYPICAL THRUST – TIME CURVES

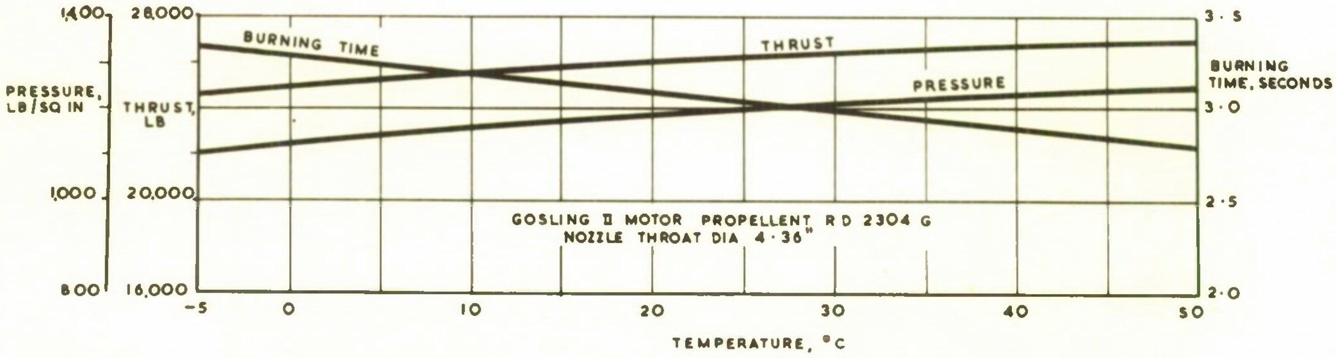



FIG. 7 VARIATION OF MEAN PRESSURE, THRUST & BURNING TIME WITH OPERATING PRESSURE

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